NextSTEPS Sustainable Transportation Energy Pathways

Biofuel opportunities and transition costs
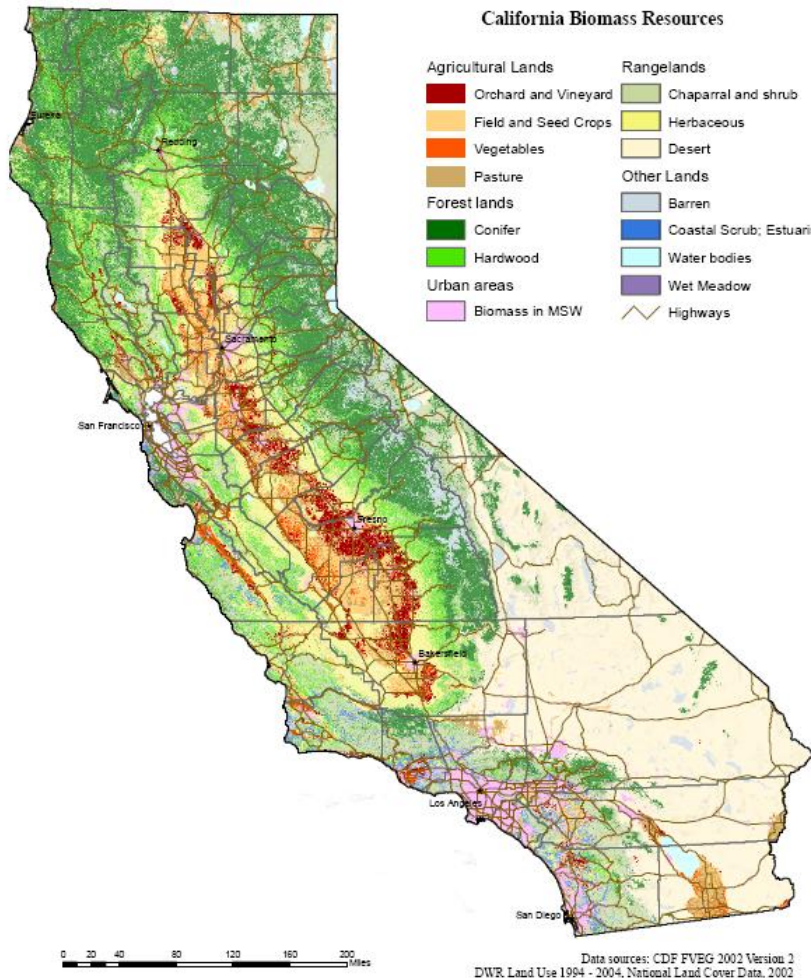
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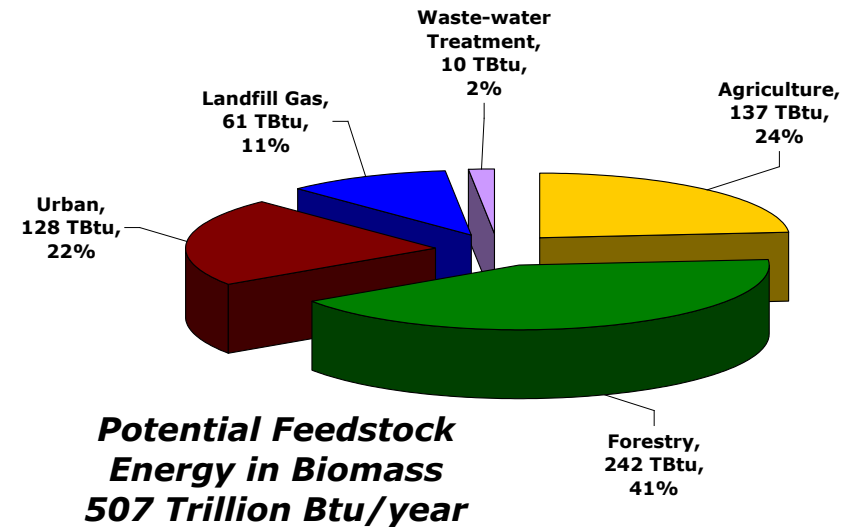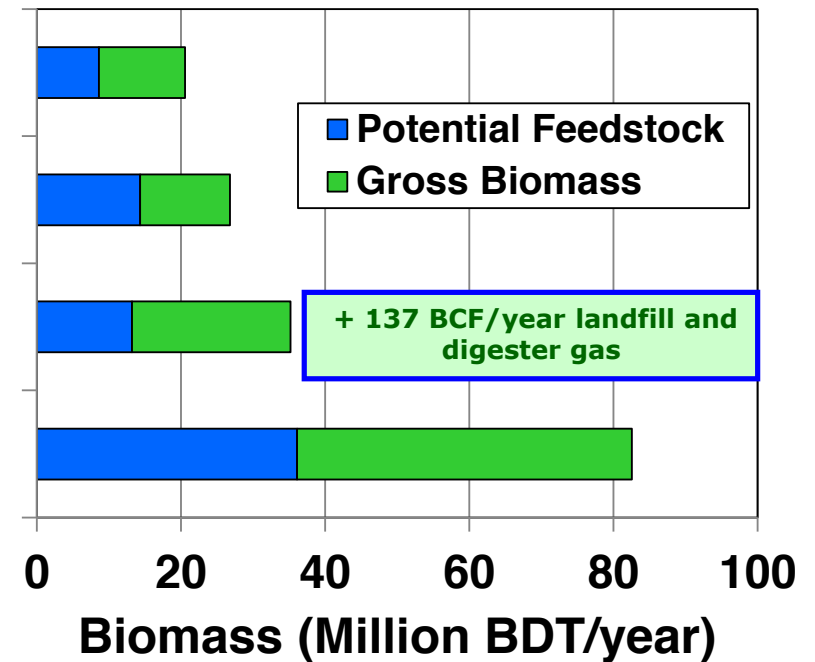
California Biomass Resources Are Diverse

Potential Feedstock Energy in Biomass 507 Trillion Btu/year

+ 137 BCF/year landfill and digester gas

Pie chart breakdown:
- Landfill Gas, 61 TBtu, 11%
- Waste-water Treatment, 10 TBtu, 2%
- Agriculture, 137 TBtu, 24%
- Urban, 128 TBtu, 22%
- Forestry, 242 TBtu, 41%

Jenkins et al. (2006) A roadmap for the development of biomass in California

CALIFORNIA BIOMASS COLLABORATIVE

Estimated Fuel Potential from California biomass residues*
(*not its economic potential)

Feedstock	Amount Technically Available	Biomethane Potential (billion cubic feet)	Biofuel Potential (million gge)
Agricultural Residue (Lignocellulosic)	3.5 M BDT[a]	-	175[h]
Animal Manure	3.8 M BDT[a]	14.6[a]	125[i]
Fats, Oils and Greases	207,000 tons[b]	(assume conversion to biodiesel)	56[j]
Forestry and Forest Product Residue	14.2 M BDT[a]	-	710[h]
Landfill Gas	110 BCF[a]	55[f]	474[i]
Municipal Solid Waste (food waste fraction)	1.2 M BDT[c]	13.1[g]	113[i]
Municipal Solid Waste (lignocellulosic fraction)	9.5 M BDT[d]	-	475[h]
Waste Water Treatment Plants	9.6 BCF (gas)[e]	4.8[f]	41[i]
Total			2,169

a. Williams, R. B., Gildart, M., & Jenkins, B. M. (2008). An Assessment of Biomass Resources in California, 2007. CEC PIER Contract 500-01-016: California Biomass Collaborative.
b. From: Wiltsee, G. (1999). Urban Waste Grease Resource Assessment: NREL/SR-570-26141. Appel Consultants, Inc. 11.2 lbs./ca-y FOG and California population of 36.96 million. Biodiesel has ~9% less energy per gallon than petroleum diesel.
c. Technical potential assumed to be 67% of amount disposed in landfill (2007). Reference (a) uses a 50% technical recovery factor for MSW stream going to landfill, however it is not unreasonable to assume higher recovery factors as market value of bioenergy product increases or for cases where biomass does not need to be separated before conversion. (waste characterization and disposal amounts are from: http://www.calrecycle.ca.gov/Publications/General/2009023.pdf)
d. 67% of mixed paper, woody and green waste and other non-food organics disposed in landfill (2007). Note (c) discusses rational for using a higher technical recovery factor than that assumed for MSW in reference (a). (waste characterization and disposal amounts are from: http://www.calrecycle.ca.gov/Publications/General/2009023.pdf)
e. From EPA Region 9; Database for Waste Treatment Plants
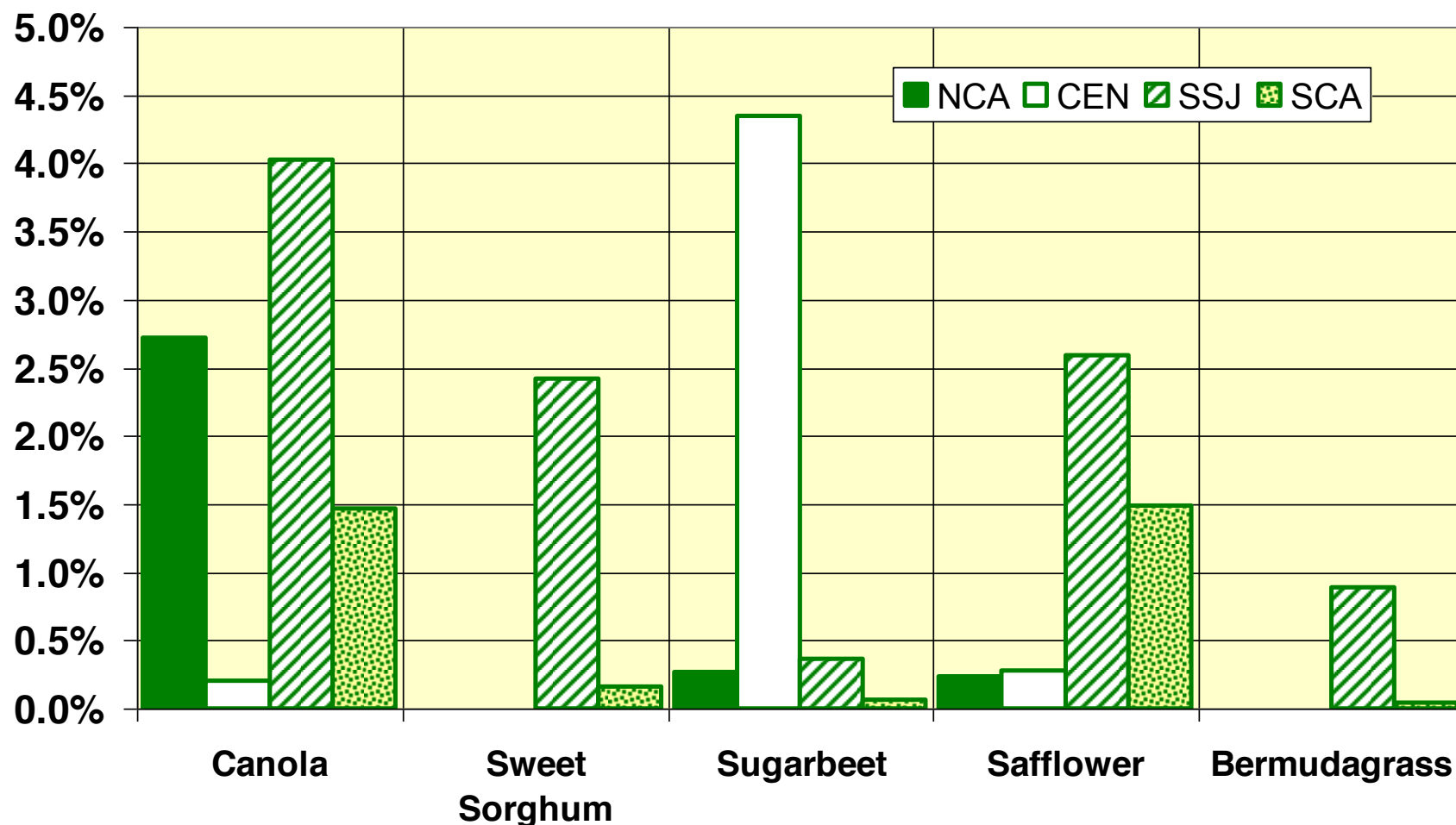f. Assumes 50% methane in gas
g. Assumes VS/TS= 0.83 and biomethane potential of 0.29g CH4/g VS
h. Using 50 gge per dry ton (75 gallons EtOH per dry ton) yield. See, for example: Anex, R. P., et al. (2010). Techno-economic comparison of biomass-to-transportation fuels via pyrolysis, gasification, and biochemical pathways. [Article]. Fuel, 89, S29–S35. doi: 10.1016/j.fuel.2010.07.015
i. ~116 ft^3 methane is equivalent to 1 gge (983 Btu/scf methane and 114,000 Btu/gallon gasoline, lower heating value basis)
j. 7.5 lbs FOG/ gallon biodiesel. Biodiesel has ~9% less energy per gallon than petroleum diesel, gives 50 M gallons diesel equivalent. 1 dge = 1.12 gge

Potential crop use for energy with favorable prices in different regions of the state (% of land in each region)


Legend: NCA, CEN, SSJ, SCA

Y-axis: 0.0%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5%, 5.0%

X-axis categories: Canola, Sweet Sorghum, Sugarbeet, Safflower, Bermudagrass

Multiple iterations of the Biomass Crop Adoption Model suggest that certain crops will be preferentially adopted in different parts of the state.

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# The vast majority of technically available biomass is lignocellulosic

- There are no off the shelf technologies to utilize this resource for liquid fuels.
  - What technologies will prove commercially viable?
  - How do they get there?

High capital costs for 1st commercial biorefineries
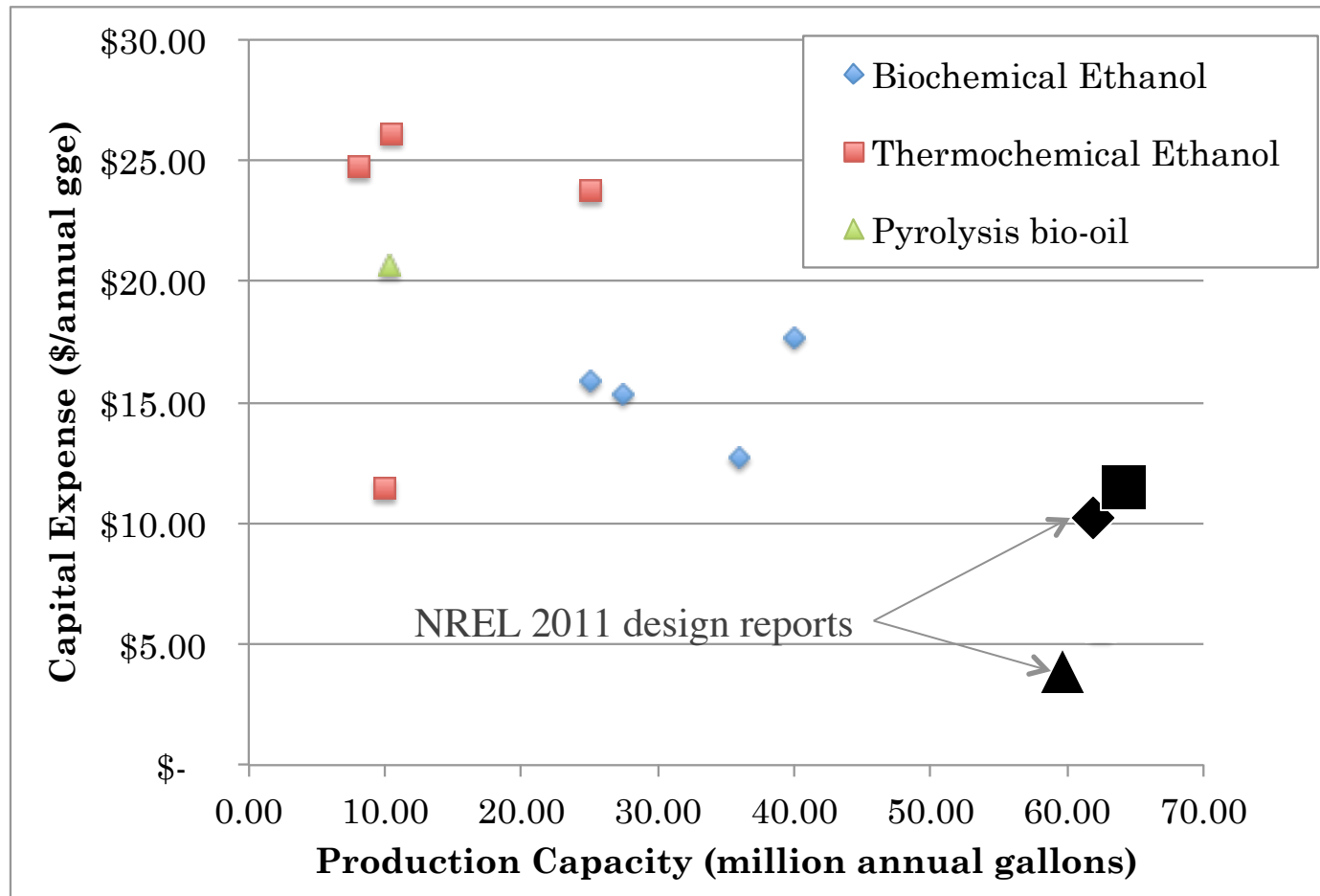
Sample capital cost estimates as reported in media/loan programs/IPO fillings.
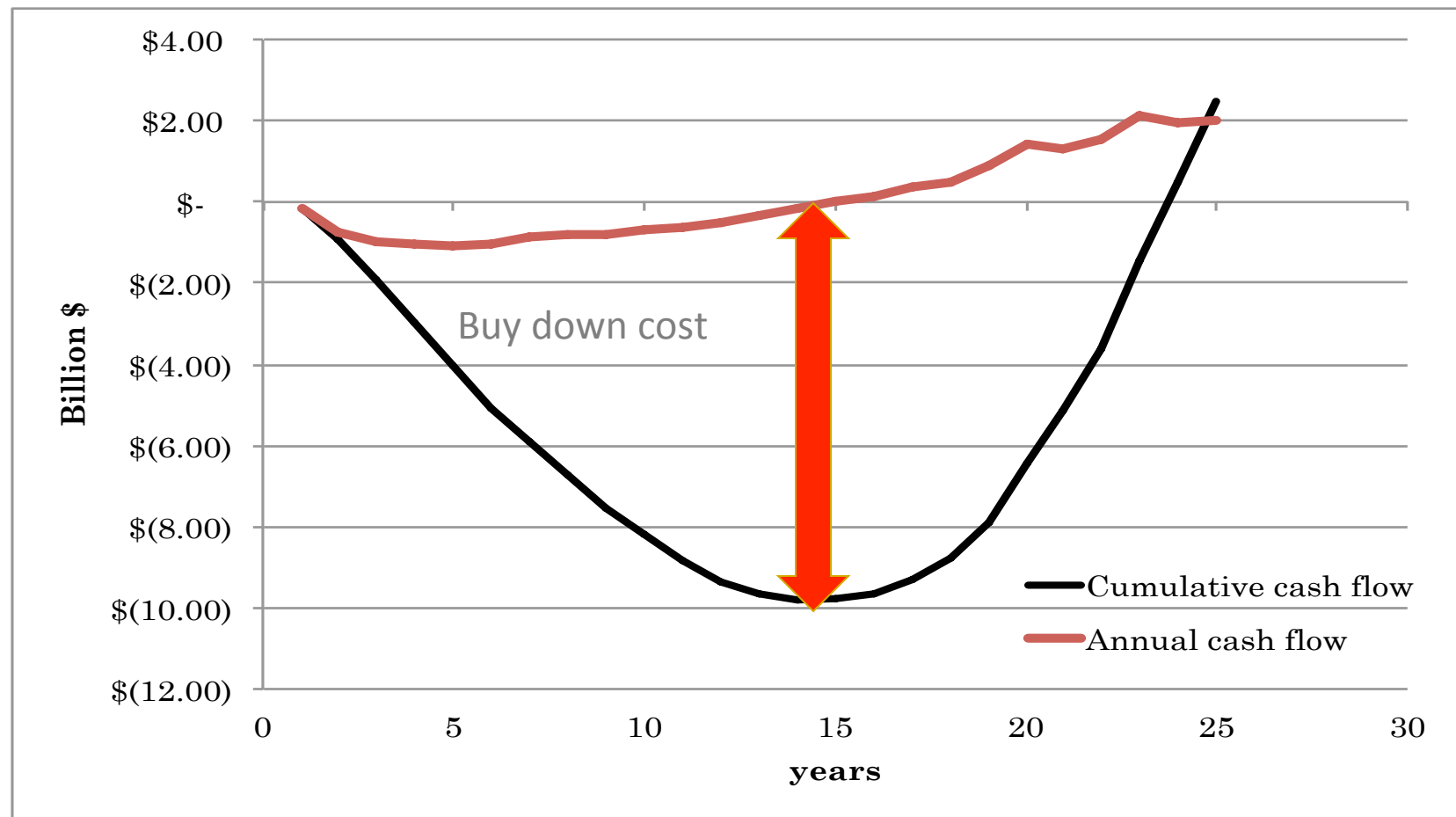
Cost path from cost estimates to mature technology
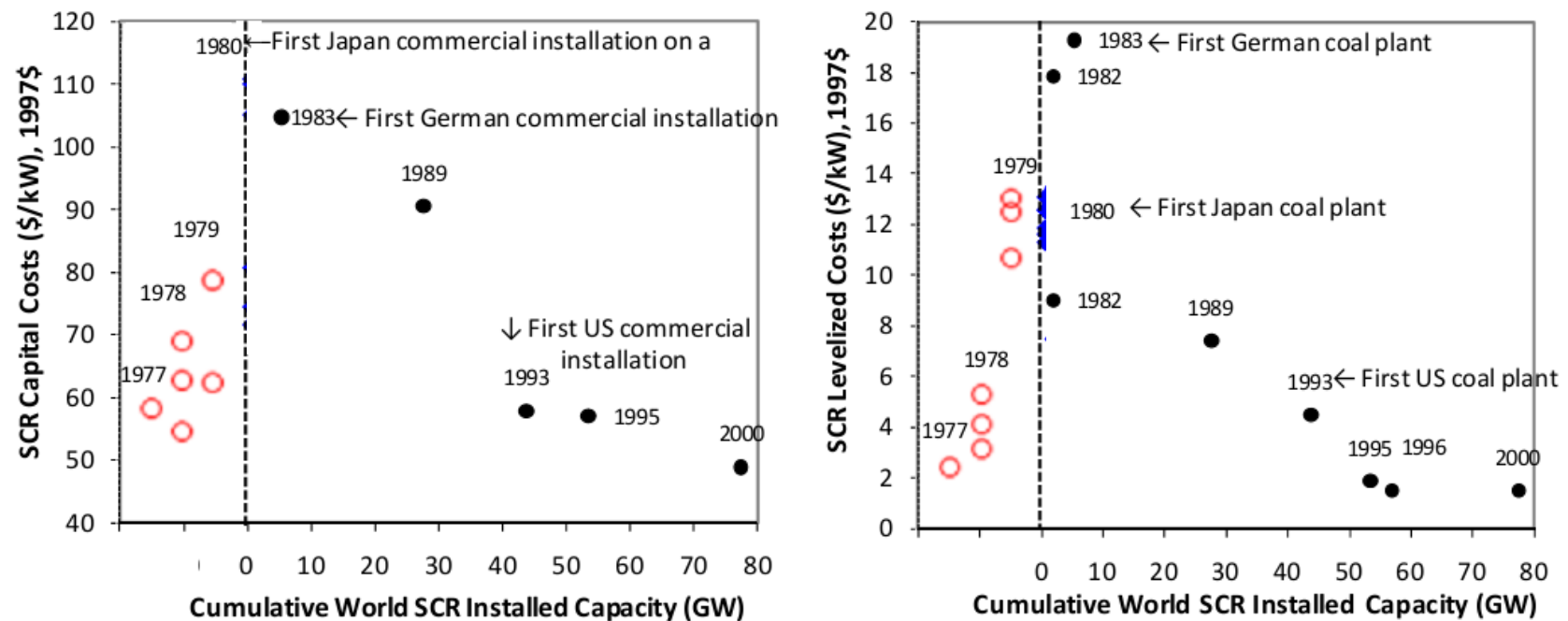
Illustrative example

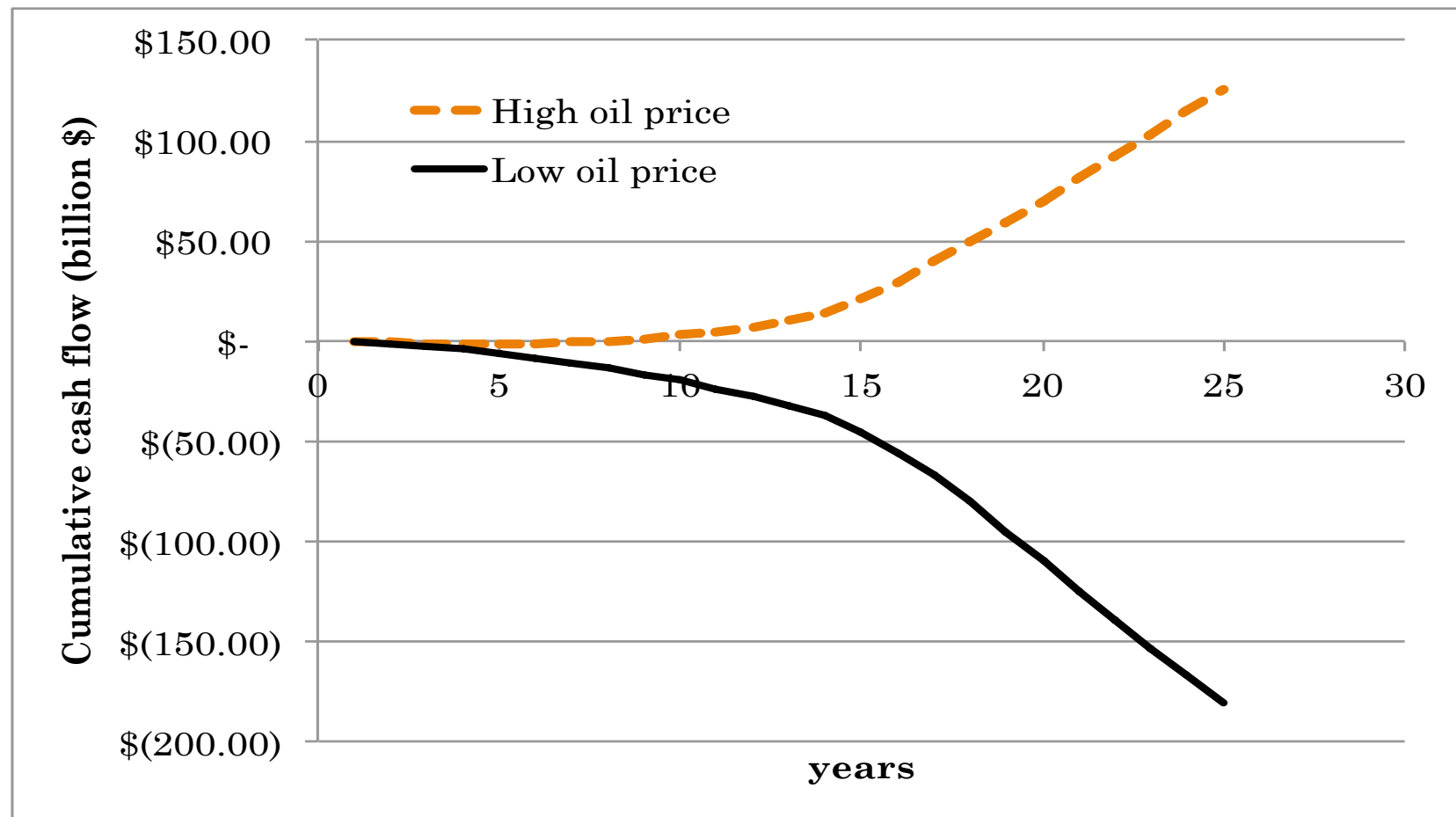*Yeh, S. and E. Rubin. (2010) Uncertainties in Technology Experience Curves for Energy-Economics Models.*

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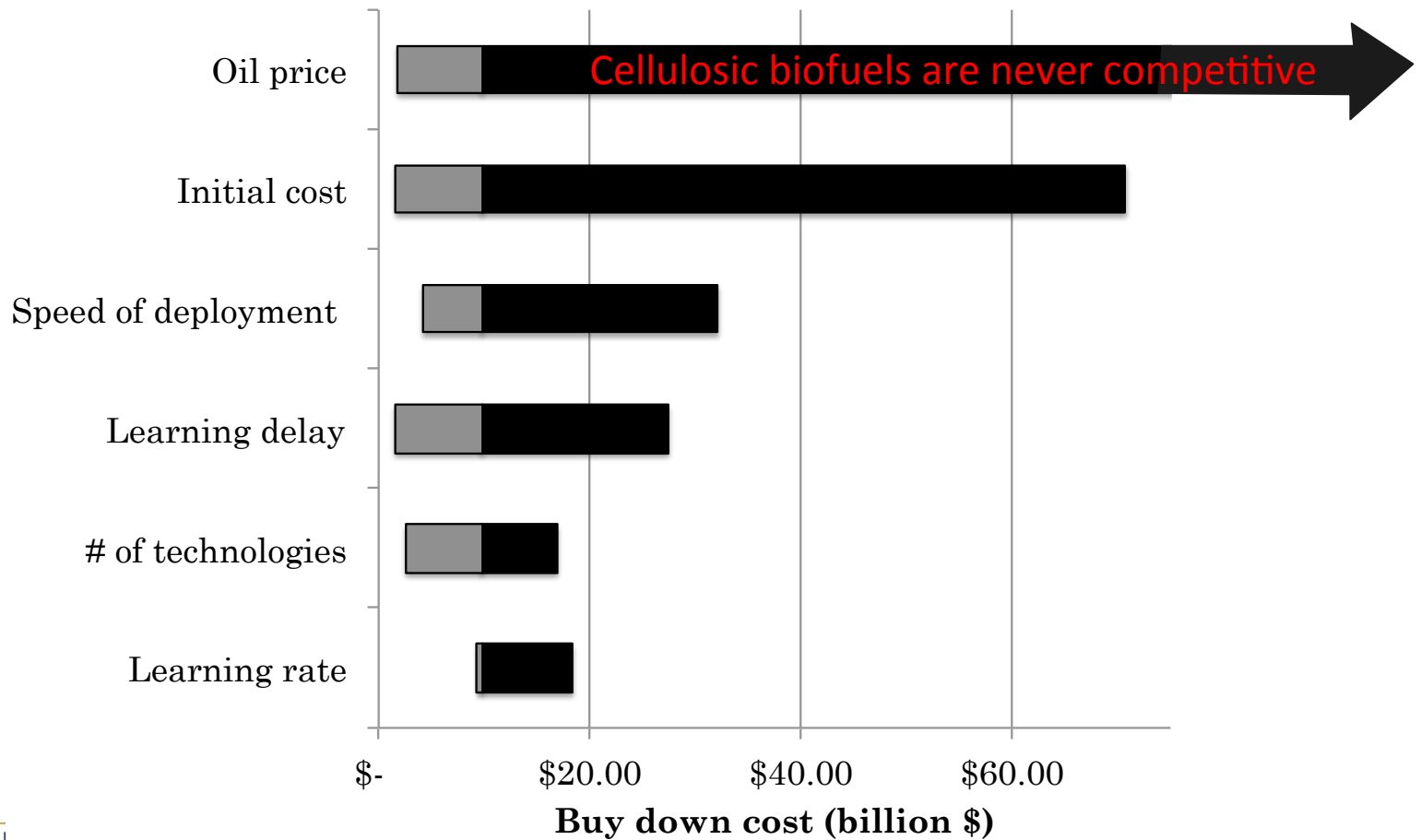
Transition cost reference case

Extreme cases

The cost of transition is uncertain

- Take home messages
  - Some scenarios do not lead to cost competitive biofuels
  - For those that do, buy down cost are between $2 and $70 billion

Tornado chart with categories (top to bottom): Oil price, Initial cost, Speed of deployment, Learning delay, # of technologies, Learning rate. An arrow on the "Oil price" bar reads "Cellulosic biofuels are never competitive."

X-axis: Buy down cost (billion $), with labels $-, $20.00, $40.00, $60.00

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Conclusion

- Lignocellulosic biomass remains the largest potential primary source for biofuels.

- Buy down cost for commercialization are estimated to be on the order of 10s of billions of dollars.

- Breakeven net present value for requires 10-40 years to occur.

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